to separate the compressed video data, the compressed audio data, the compressed title data and the sub-information. The compressed video data is stored in a buffer memory **249** from which it is expanded in expansion circuit **250**, processed in a post processor **256**, for example, as may be needed to conceal errors, and reconverted back to analog form by digital-to-analog converter **251**. Expansion circuit **250** operates in accordance with the MPEG-1 or MPEG-2 standard such that the original video information is recovered.

Post processor **256** also is adapted to superimpose graphical title information on the recovered video data, as will be described below, such that the recovered title data may be suitably displayed, as by superposition on a video picture.

The separated audio data is supplied from demultiplexor **248** to an audio buffer memory **252** from which it is expanded in an expansion circuit **253** and reconverted to analog form by digital-to-analog convertor **254**. Expansion circuit **253** operates in accordance with the MPEG-1 or MPEG-2 or mini disc standard, as may be desired. If the audio data that is recorded on disc **100** has not been compressed, expansion circuit **253** may be omitted or bypassed.

As depicted in FIG. **33**, the sub-information separated by demultiplexor **248** is supplied as a direct output signal, consistent with the representation shown in FIG. **32** wherein such subinformation is not processed prior to being supplied to multiplexor **107** and no processing subsequent to demultiplexor **248** is illustrated.

The separated title data is applied to title buffer memory **233** from demultiplexor **248** from which the title data is decoded by a title decoder **260** that operates in a manner inverse to the operation of compression circuit **112** (FIG. **32**). That is, decoder **260** may carry out an inverse variable length decoding operation. The decoded title data is supplied to post processor **256** for superposition onto the video information that has been played back from the optical disc.

Demultiplexor **248** monitors the remaining capacities of buffer memories **249**, **252** and **233** to sense when these memories are relatively empty or filled. The purpose of monitoring the remaining capacities of the buffer memories is to assure that data overflow therein does not occur.

System controller **230** and user interface **231** of FIG. **33** are the same as system controller **230** and user interface **231** in FIG. **2**.

While the present invention has been particularly shown and described with reference to preferred embodiments, it will be readily apparent to those of ordinary skill in the art that various changes and variations may be made without departing from the spirit and scope of the invention. To the extent that such variations and changes have been mentioned herein, the appended claims are to be interpreted as including such variations and changes as well as all equivalents to those features which have been particularly disclosed.

What is claimed is:

1. A method of recording data on an optical disk having a diameter less than 140 mm, a thickness of 1.2 mm±0.1 mm and a recording area divided into a lead-in area, a program area and a lead-out area, said method comprising the steps of: providing user information for recording in a plurality of sectors in user tracks; providing table of contents (TOC) information for recording in a plurality of sectors in at least one TOC track, said TOC information including addresses of respective start sectors, each identifying a start sector of a respective user track; encoding both said user information and said TOC information in a long distance error correction code having at least eight parity symbols; modulating the

encoded user and TOC information; recording the modulated, encoded TOC information as embossed pits in said at least one TOC track in said lead-in area; and recording the modulated, encoded user information as embossed pits in said user tracks in said program area with a track pitch in the range between 0.646 μm and 1.05 μm.

2. The method of claim 1 wherein each of said steps of recording is operative to record said embossed pits with a linear density in the range between 0.237 μm per bit and 0.378 μm per bit.

3. The method of claim 1 wherein the step of recording embossed pits in said program area is operative to record said program area in a portion of the disk having a radius of from 20 mm to 65 mm.

4. The method of claim 1 wherein said step of recording the modulated encoded TOC information includes the step of recording is said program area modulated, encoded TOC information substantially identical to the TOC information recorded in said lead-in area.

5. The method of claim 1 wherein said step of recording said TOC information includes the steps of recording TOC identification data for identifying a location of said at least one TOC track, recording a data configuration of said at least one TOC track, and recording a sector configuration of each of said plurality of sectors.

6. The method of claim 1 wherein said TOC information includes data representative of disk size.

7. The method of claim 1 wherein said TOC information includes data representative of a time code associated with said user information.

8. The method of claim 1 wherein said user information is reproducible at a selected one of plural playback speeds; and said step of recording said TOC information includes the step of recording data representative of said selected playback speed.

9. The method of claim 1 wherein the step of encoding comprises encoding said user and TOC information in a convolution code.

10. The method of claim 1 wherein said TOC information is representative of record/playback characteristics, diameter, recording capacity and number of record tracks of said optical disk.

11. The method of claim 10 wherein said record/playback characteristics of said optical disk represent a read only disk, a write once disk or an erasable disk.

12. The method of claim 1 wherein said step of modulating comprises run length limited (RLL) modulating said encoded user and TOC information.

13. The method of claim 12 wherein said RLL modulating is (2.10) modulation, such that successive transitions are separated by no less than 2 data bit cells and by no more than 10 data bit cells.

14. The method of claim 13 wherein said step of modulating further comprises converting n-bit data words representing said user and TOC information to 2n-bit information words for recording.

15. The method of claim 1 wherein said step of encoding information in said long distance error correction code is comprised of receiving input information data; inserting C2 and C1 hold sections at predetermined locations in said input data and thereby forming preliminary C1 words comprised of plural data symbols; generating C2 parity symbols in response to a predetermined number of data symbols of the same number of preliminary C1 words and replacing a C2 hold section in a preliminary C1 word with said C2 parity symbols to form a precursory C1 word, generating C1 parity symbols in response to a precursory C1 word and inserting

said C1 parity symbols into a C1 hold section to form a C1 code word, and using a pre-established number of said C1 code words as said long distance error correction encoded data.

16. The method of claim **15** wherein said step of recording comprises recording the symbols of the C1 code words in a symbol sequence different from the symbol sequence of said preliminary C1 words.

17. The method of claim **16** wherein a preliminary C1 code word is comprised of odd and even symbols and wherein said step of recording records the odd symbols together in an odd group and records the even symbols together in an even group.

18. The method of claim **17** wherein each C1 code word is formed of m symbols including m−n C1 parity symbols, where m and n are integers; and wherein:

$$k=m\times i+2\times j-m, \text{ when } j<m/2$$

$$k=m\times i+2\times j-(m-1), \text{ when } j\geqq m/2,$$

where i is the sequential order of the preliminary C1 words of input data, j is the sequential order of the m symbols in each preliminary C1 code word, and k is the order in which the m symbols are recorded on the disk.

19. The method of claim **1** wherein said step of modulating comprises supplying said TOC and user information as n-bit bytes, reading from a selected one of plural storage tables a 2n-bit symbol in response to a supplied n-bit byte, and selecting said one storage table as a function of the preceding 2n-bit symbol that had been read.

20. The method of claim **19**, wherein successive 2n-bit symbols are run length limited.

21. The method of claim **20** wherein different 2n-bit symbols are stored respectively in at least two of said storage tables for the same n-bit byte.

22. The method of claim **21** wherein the 2n-bit symbols stored in one of said two storage tables exhibit positive digital sum value (DSV) and the 2n-bit symbols stored in the other of said two storage tables exhibit negative DSV.

23. The method of claim **22** wherein the step of selecting said one storage table is determined as a function of the number of "0" bits in which the preceding 2n-bit symbol terminates and accumulated DSV of a predetermined number of preceding 2n-bit symbols.

24. The method of claim **1** wherein each sector in at least said user tracks includes a sector header at a leading portion thereof; and said step of recording user information includes recording in said sector header, a sector sync pattern, a sector address, an error detection code, and subcode data.

25. The method of claim **24** wherein said subcode data in a given sector includes a subcode identifier and subcode information of a type identified by said subcode identifier.

26. The method of claim **25** wherein said subcode identifier is a subcode address.

27. The method of claim **25** wherein said subcode information includes track identifying data which identifies the track in which said given sector is recorded, copyright data which indicates whether user information in said track may be copied, and application identifying data which identifies a predetermined application allotted to said user information in said track.

28. The method of claim **25** wherein said step of encoding said user information comprises compressing a predetermined display sequence of picture data in accordance with selectively different types of compression-encoding technique, and said subcode information includes type identifying information for identifying the type of compression-

encoding technique that is used to compress the data recorded in said given sector and sequence information for identifying the location in said display sequence of the picture represented by the compressed picture data that is recorded in said given sector.

29. The method of claim **25** wherein said user information is variable over time, and said subcode information includes time code data representing time information at which said user information is recorded.

30. The method of claim **25** wherein said user information is picture information representing a respective picture; and said step of recording comprises recording said picture information in at least one sector in said user tracks, and recording as subcode information first distance information representing the distance from said given sector to the sector in which picture information representing a next preceding picture is recorded and second distance information representing the distance from said given sector to the sector in which picture information representing a next following picture is recorded.

31. The method of claim **30** wherein said step of recording picture information comprises recording said picture information in a lead sector and at least one following sector.

32. The method of claim **31** wherein said step of encoding said user information comprises compressing picture data to selectively form intraframe encoded picture data or predictively encoded picture data; and each of said first and second distance information represents the distance from said given sector to the lead sector in which intraframe encoded picture data is recorded.

33. Apparatus for recording data on an optical disk having a diameter less than 140 mm, a thickness of 1.2 mm±0.1 mm and a recording area divided into a lead-in area, a program area and a lead-out area, said apparatus comprising: input means for providing user information for recording in a plurality of sectors in user tracks and table of contents (TOC) information for recording in a plurality of sectors in at least one TOC track, said TOC information including addresses of respective start sectors, each identifying a start sector of a respective user track; encoding means for encoding both said user information and said TOC information in a long distance error correction code having at least eight parity symbols; modulator means for modulating the encoded user and TOC information; and recording means for recording the modulated, encoded TOC information as embossed pits in said at least one TOC track in said lead-in area and for recording the modulated, encoded user information as embossed pits in said user tracks in said program area with a track pitch in the range between 0.646 μm and 1.05 μm.

34. The apparatus of claim **33** wherein said recording means is operative to record said embossed pits with a linear density in the range between 0.237 μm per bit and 0.378 μm per bit.

35. The apparatus of claim **33** wherein said recording means is operative to record said program area in a portion of the disk having a radius of from 20 mm to 65 mm.

36. The apparatus of claim **33** wherein said recording means is operative to record in said program area modulated, encoded TOC information substantially identical to the TOC information recorded in said lead-in area.

37. The apparatus of claim **33** wherein said TOC information includes TOC identification data for identifying a location of said at least one TOC track and configuration data for identifying a data configuration of said at least one TOC track and a sector configuration of each of said plurality of sectors.

38. The apparatus of claim **33** wherein said TOC information includes data representative of disk size.

39. The apparatus of claim **33** wherein said TOC information includes data representative of a time code associated with said user information.

40. The apparatus of claim **33** wherein said user information is reproducible at a selected one of plural playback speeds; and said TOC information includes data representative of said selected playback speed.

41. The apparatus of claim **33** wherein said encoding comprises a convolution code encoder.

42. The apparatus of claim **33** wherein said TOC information is representative of record/playback characteristics, diameter, recording capacity and number of record tracks of said optical disk.

43. The apparatus of claim **42** wherein said record/playback characteristics of said optical disk represent a read only disk, a write once disk or an erasable disk.

44. The apparatus of claim **33** wherein said modulator means is a run length limited (RLL) modulator.

45. The apparatus of claim **44** wherein said RLL modulator performs (**2.10**) modulation, such that successive transitions are separated by no less than 2 data bit cells and by no more than 10 data bit cells.

46. The apparatus of claim **45** wherein said modulator includes means for converting n-bit data words representing said user and TOC information to 2n-bit information words for recording.

47. The apparatus of claim **33** wherein said encoding means is comprised of means for receiving said user and TOC information as input data; means for inserting C2 and C1 hold sections at predetermined locations in said input data to thereby form preliminary C1 words comprised of plural data symbols; means for generating C2 parity symbols in response to a predetermined number of data symbols of the same number of preliminary C1 words; means for replacing a C2 hold section in a preliminary C1 word with said C2 parity symbols to form a precursory C1 word; means for generating C1 parity symbols in response to a precursory C1 word; and means for inserting said C1 parity symbols into a C1 hold section to form a C1 code word, with a pre-established number of said C1 code words constituting said long distance error correction encoded data.

48. The apparatus of claim **47** wherein said recording means further includes means for recording the symbols of the C1 code words in a symbol sequence different from the symbol sequence of said preliminary C1 words.

49. The apparatus of claim **48** wherein a preliminary C1 code word is comprised of odd and even symbols and wherein said means for recording is operative to record the odd symbols together in an odd group and the even symbols together in an even group.

50. The apparatus of claim **49** wherein each C1 code word is formed of m symbols including m−n C1 parity symbols, where m and n are integers; and wherein:

$$k = m \times i + 2 \times j - m, \text{ when } j < m/2$$

$$k = m \times i + 2 \times j - (m-1), \text{ when } j \geqq m/2,$$

where i is the sequential order of the preliminary C1 words of input data, j is the sequential order of the m symbols in each preliminary C1 code word, and k is the order in which the m symbols are recorded on the disk.

51. The apparatus of claim **33** wherein said modulator means comprises an n-to-2n modulator in which said TOC and user information are supplied as n-bit bytes, including plural storage tables, each for storing 2n-bit symbols corre-

sponding to respective n-bit bytes; means for reading from a selected one storage table a 2n-bit symbol in response to a supplied n-bit byte; and means for selecting said storage table as a function of the preceding 2n-bit symbol that had been read.

52. The apparatus of claim **51**, wherein successive 2n-bit symbols are run length limited.

53. The apparatus of claim **52** wherein at least two of said storage tables store different 2n-bit symbols for the same n-bit byte.

54. The apparatus of claim **53** wherein the 2n-bit symbols stored in one of said two storage tables exhibit positive digital sum value (DSV) and the 2n-bit symbols stored in the other of said two storage tables exhibit negative DSV.

55. The apparatus of claim **54** wherein said means for selecting said one storage table includes means for sensing the number of "0" bits in which the preceding 2n-bit symbol terminates, means for determining the accumulated DSV of a predetermined number of preceding 2n-bit symbols and means for selecting the storage table as a function of the sensed number of "0" bits and the accumulated DSV.

56. The apparatus of claim **33** wherein each sector in at least said user tracks includes a sector header at a leading portion thereof; and said recording means is operative to record in said sector header, a sector sync pattern, a sector address, an error detection code, and subcode data.

57. The apparatus of claim **59** wherein said subcode identifier is a subcode address.

58. The apparatus of claim **59** wherein said subcode information includes track identifying data which identifies the track in which said given sector is recorded, copyright data which indicates whether user information in said track may be copied, and application identifying data which identifies a predetermined application allotted to said user information in said track.

59. The apparatus of claim **56** wherein said subcode data in a given sector includes a subcode identifier and subcode information of a type identified by said subcode identifier.

60. The apparatus of claim 59 wherein said encoding means comprises means for compressing a predetermined display sequence of picture data in accordance with selectively different types of compression-encoding techniques, and said subcode information includes type identifying information for identifying the type of compression-encoding technique that is used to compress the data recorded in said given sector and sequence information for identifying the location in said display sequence of the picture represented by the compressed picture data that is recorded in said given sector.

61. The apparatus of claim 59 wherein said user information is variable over time, and said subcode information includes time code data representing time information at which said user information is recorded.

62. The apparatus of claim 59 wherein said user information is picture information representing a respective picture; and said recording means is operative to record said picture information in at least one sector in said user tracks, and to record as subcode information first distance information representing the distance from said given sector to the sector in which picture information representing a next preceding picture is recorded and second distance information representing the distance from said given sector to the sector in which picture information representing a next following picture is recorded.

63. The apparatus of claim 62 wherein said recording means is further operative to record picture information in a lead sector and at least one following sector.

64. The apparatus of claim 63 wherein said encoding means includes means for compressing picture data to selectively form intraframe encoded picture data or predictively encoded picture data; and each of said first and second distance information represents the distance from said given sector to the lead sector in which intraframe encoded picture data is recorded.

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65. A method of recording data on an optical disk having a diameter less than 140 mm and a recording area divided into a lead-in area, a program area and a lead-out area, said method comprising the steps of: providing user information for recording in a plurality of sectors in user track regions; providing control information for recording in a plurality of sectors in at least one control information region, said control information including addresses of respective start sectors, each identifying a start sector of a respective user track; encoding both said user information and said control information in a long distance error correction code having at least eight parity symbols; modulating the encoded user and control information; recording the modulated, encoded control information in said at least one control information region in either said lead-in area or said program area; and recording the modulated, encoded user information in said user track regions in said program area with a track pitch in the range between 0.646 μm and 1.05 μm.

66. Apparatus for recording data on an optical disk having a diameter less than 140 mm and a recording area divided into a lead-in area, a program area and a lead-out area, said apparatus comprising: input means for providing user information for recording in a plurality of sectors in user track regions and control information for recording in a plurality of sectors in at least one control information region, said control information including addresses of respective start sectors, each identifying a start sector of a respective user track; encoding means for

encoding both said user information and said control information in a long distance error correction code having at least eight parity symbols; modular means for modulating the encoded user and control information; and recording means for recording the modulated, encoded control information in said at least one control information region in either said lead-in area or said program area and the modulated, encoded user information in said user track regions in said program area with a track pitch in the range between 0.646 μm and 1.05 μm.

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